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United States
Department of
Agriculture

Forest Service

Alaska
Region

Forest Pest Management Report

R-10-87-4

Spruce beetle in Glacier Bay National Park:1986 Update

July 1987

3430

BIOLOGICAL EVALUATION R-10-87-4

SPRUCE BEETLE IN GLACIER BAY NATIONAL PARK:1986 UPDATE

JULY 1987

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ABSTRACT

The spruce beetle infestation in Glacier Bay National Park was re-examined in 1986. Aerial reconnaissance indicated that nearly 15,000 acres are now affected, with spruce mortality on those acres ranging from 5 to 70%. Very little spruce beetle activity was noted on the 45 fifth-acre monitoring plots in 1986, although 47 trees died of other causes. Cumulative spruce mortality on the plots is now 47%, and only 35% of the live spruce have never been attacked by the spruce beetle.

Increment cores were examined from 172 dead trees. Most trees had been growing very slowly for at least the past 20 years. Growth rates on virtually all these trees were far below the standard of 1 mm/year which would be considered vigorous growth for the stand.

Some stand deterioration is becoming evident in areas where spruce mortality was first noticed in the late 1970's. Over 7% of all the dead trees have broken boles or have been windthrown, with the highest deterioration being evident on Young Island (nearly 20% of the dead trees have stem breakage).

Beetle attack data were collected from 10-35 feet up the boles of 53 dead spruces. Spruce beetle attack levels at breast height were often different from attack levels higher in the bole. Many dead trees contained high numbers of secondary bark beetles at midbole.

INTRODUCTION

The lowland forests of Glacier Bay National Park continue to be affected by the spruce beetle, Dendroctonus rufipennis. The on-going infestation which began in the late 1970's has been documented in previous reports (Eglitis 1982; 1985; 1986). As of 1985, over 12,000 acres of Sitka spruce forest had been infested by the spruce beetle.

Forest Pest management staff from the USDA Forest Service has been involved in various assessment activities in the Park since 1981. One of the evaluations carried out in the Park has involved the annual monitoring of fifth-acre plots established in 1982. Information collected from these 45 plots has been used to evaluate annual spruce mortality and to predict future trends in spruce beetle populations. The purpose of this report is to present the most recent information from these monitoring plots (collected in August 1986) and to update the status of the spruce beetle in Glacier Bay National Park.

METHODS

Aerial survey

The spruce beetle infestation in the Park was surveyed during the aerial reconnaissance of forest pest damage done annually by the Forest Pest Management staff. An updated map of the infestation was prepared from aerial sketch-mapping.

Fifth-acre monitoring plots

The 45 fifth-acre plots were revisited in August, 1986, and all spruces were examined to determine new mortality since 1985. Additional strip attacks or unsuccessful attacks (pitchouts) were noted on trees which were still alive.

Increment cores were taken from most of the dead trees in order to determine pre-infestation growth rates.

On Lester Island, 53 trees were climbed using aluminum tree ladders. The trees chosen for climbing were ones where the cause of mortality was not readily apparent at breast height where most of our observations are normally made. On these 53 trees we looked for evidence of bark beetle galleries at various heights along the bole from 10 to 35 feet above the ground. This information was compared to the observations we had made at breast height.

RESULTS AND DISCUSSION

Aerial survey

The 1986 survey results showed that the total affected acreage in Glacier Bay National Park is now nearly 15,000 acres. On the west side of Sitakaday Narrows some additional recent mortality was noted in the lower foothills. Expansion on the west side has been very slight in recent years, however. On the east side, the infestation intensified on the Beardslee Islands, especially on Lester Island and on the large island to the northeast. Areas previously lightly infested (Bartlett Lake area) now have spruce mortality in excess of 10%. South of Bartlett Cove, cumulative spruce mortality is around 20% (Figure 1). The northernmost extension of spruce mortality is at the northern end of Hutchins Bay where 10-15% of the spruce have died in some stands. As shown in Figure 1, the extent of tree mortality is extremely variable throughout the infested area. North of Ripple Cove and on Young Island, over half the spruce are dead, while mortality is lower in the easternmost part of the infestation. Acreage figures are shown in the following table for various levels of spruce mortality:

% Mortality	Acres affected
70	1790
60	1220
50	2950
40	590
35	1210
30	490
20	2760
15	2650
10	770
5	130
	14560

Fifth-acre monitoring plots

Spruce beetle activity and spruce mortality were not as extensive on the plots in 1986 as in the previous year. Observations made in August 1986 are summarized below in Table 1.

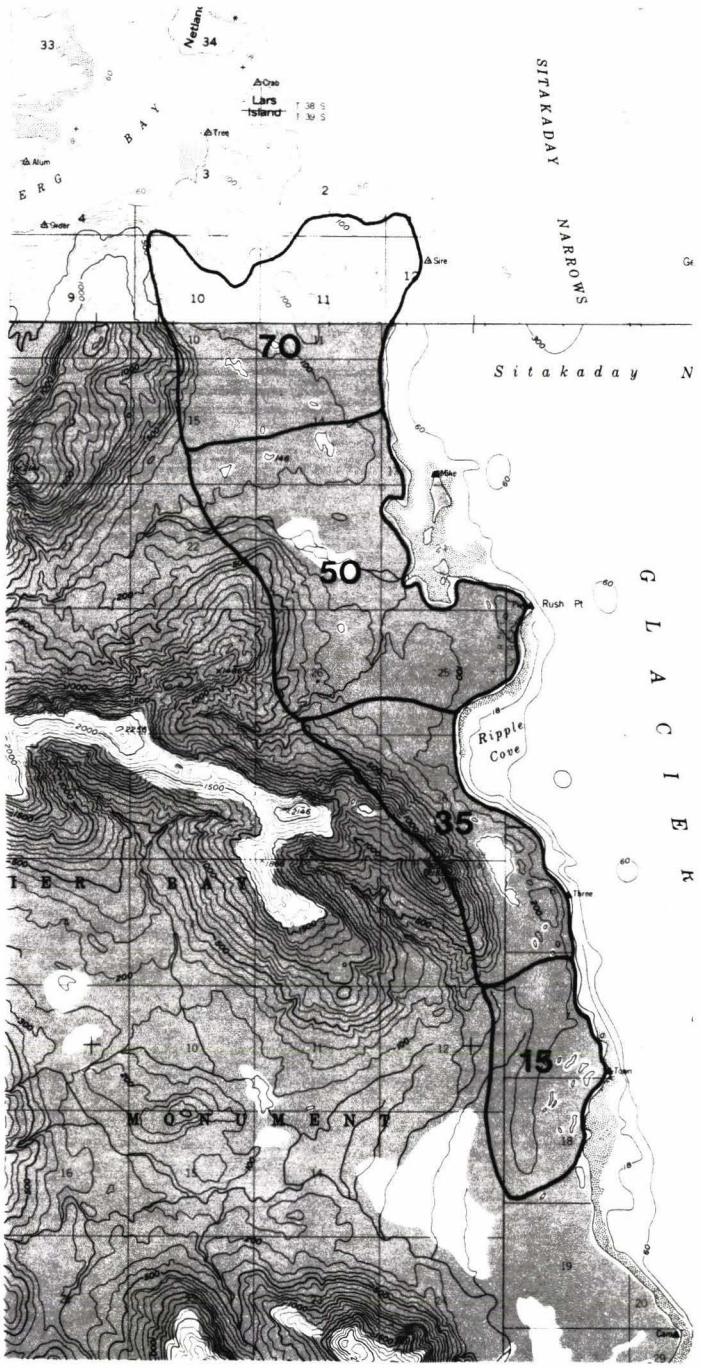

Figure 1. Distribution of spruce mortality in Glacier Bay National Park as of August 1986. Numbers in polygons represent percentage of trees dead in the stands.

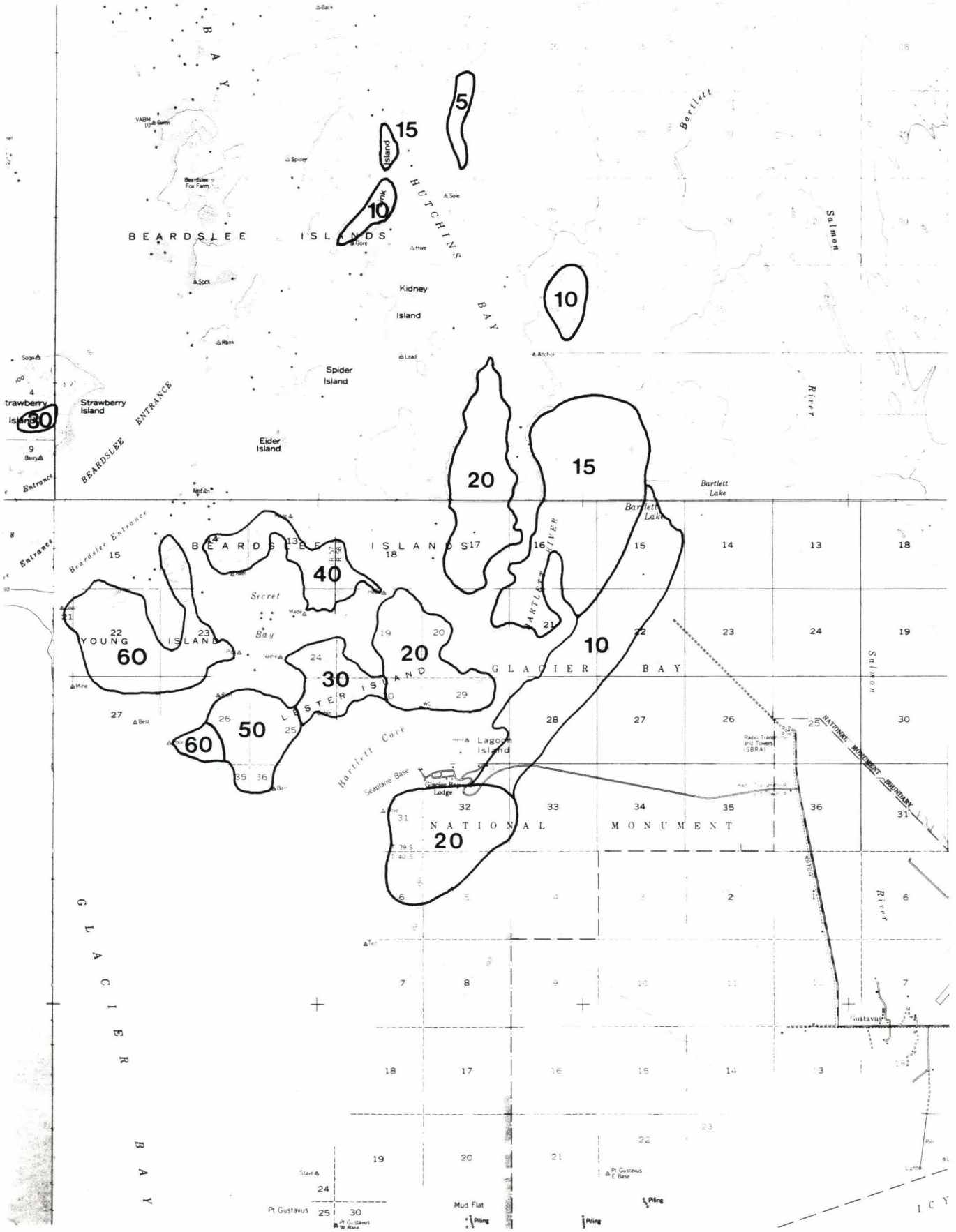
5
15
10
10
20
15
40
60
30
50
60
20
20
10
BEARDSLEE ISLANDS
HUTCHINSON BAY
Kidney Island
Spider Island
Strawberry Island
BEARDSLEE ENTRANCE
Eider Island
Bartlett Lake
BARTLETT RIVER
Secret Bay
YOUNG ISLAND
LESTER ISLAND
GLACIER BAY
Bartlett Cove
Lagoon Island
Seaplane Base
Glacier Bay Lodge
NATIONAL MONUMENT
NATIONAL MONUMENT BOUNDARY
Salmon River
Gustavus
Pt Gustavus
Mud Flat
Piling
ICY

Table 1

1986 spruce mortality and bark beetle attacks
on fifth-acre plots in six sampling areas.
Glacier Bay National Park, August 1986

Area	# plots	1986 Beetle Kill	Beetle kill by add SA*	1985 BK** not det'd in 1985	Dead-other	1986 Strip Attack	1986 PO's ***
Berg Bay	8	-	-	1	3	1	7
Ripple Cove	8	-	-	-	8	-	3
Lester Island	18	1	1	12	28	6	21
Bartlett Lk Tr	2	-	-	1	1	4	-
S. Bartlett Cv	4	-	1	1	7	3	2
Young Island	5	-	-	-	-	-	1
Total 1986	45	1	2	15	47	14	34
Total 1985	45	14	11	23	92	46	32

* Additional strip attacks on trees attacked in previous years
** BK = beetle kill not detected in 1985
*** PO = pitchouts (unsuccessful attacks)

A total of 65 plot trees died between the 1985 and 1986 season. Most of these trees died of causes other than the spruce beetle (Table 1). An additional 15 trees (mostly from Lester Island plots) were undetected beetle kills from 1985 (presumed alive at the time), and three trees were killed in 1986. These mortality figures are substantially lower than the figures from 1985, shown at the bottom of Table 1 for comparison. New strip attacks were considerably fewer in 1986 (14) than in 1985 (46). Unsuccessful attacks on plot trees were comparable in 1986 and 1985. Most of the mortality was noted on the Lester Island plots with very little spruce beetle activity elsewhere (Table 1).

The cumulative totals of spruce mortality and bark beetle activity after the 1986 season are shown in Table 2. Nearly half the spruce on the monitoring plots have died, ranging from 31% dead at the Ripple Cove plots to 60% dead on Young Island (Table 2). Of the 1025 plot trees that are alive, about 10% have dead strips from bark beetle attacks and 55% have pitchouts (unsuccessful attacks). Only 35 % of the live plot trees have not been attacked by the spruce beetle (Table 2).

Table 2

Condition of spruce trees on 45 monitoring plots in Glacier Bay National Park after 1986 examination

Area	Hemlock + Cottonwood	SPRUCE ALIVE Unattacked	SPRUCE ALIVE Pitchout	SPRUCE ALIVE Dead Strip	SPRUCE DEAD	Spruce Total	% Spruce Dead	Total Trees	% Trees Dead
Berg Bay	140	29	48	5	42	124	34	264	16
Ripple Cove	98	107	85	9	91	292	31	390	23
Lester Island	122	136	294	58	549	1037	53	1159	47
Bartlett Lake Trail	35	16	19	4	32	71	45	106	30
South Bartlett Cove	45	66	60	12	68	206	33	251	27
Young Island	25	16	48	12	117	193	61	218	54
Total	465	370	554	100	899	1923	47	2388	38

Increment cores

Growth rings have been examined on increment cores taken from 172 dead trees. Most of these cores came from trees on Lester Island (117 Of 172). The ages at time of death of the cored trees are shown in Figure 2.

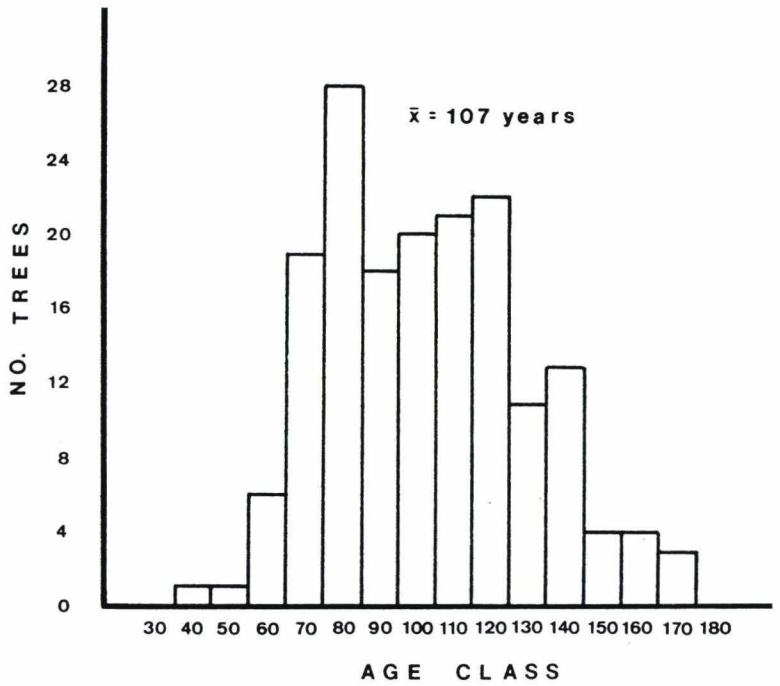

Figure 2. Ages at time of death of 172 spruces on fifth-acre monitoring plots. Glacier Bay National Park.

The trees ranged in age from 47 to 174 years, and averaged 107 ± 27 years old. Seven trees were over 160 years old, five of which were on plots along the Bartlett Lake Trail.

The diameters of these dead trees ranged from 1.1" to 25.7" and averaged 12.2 ±5.4" (Figure 3). Trees of all sizes have died from various causes including suppression, bark beetle attack, and other unidentified causes.

The data from all cored trees were combined in order to test the relationship between tree age and diameter (Figure 4). The correlation between age and diameter was weak (r^2 = 0.376) since some trees appeared to have had extremely good growing conditions and others persisted for many years in a suppressed condition. These data of tree ages and diameters indicate that perhaps there is less uniformity in the spruce forest than was previously believed. Even though the entire forest can be thought of as young, there is considerable variation in tree age (Figures 3, 4), and diameter is not a good predictor of tree age.

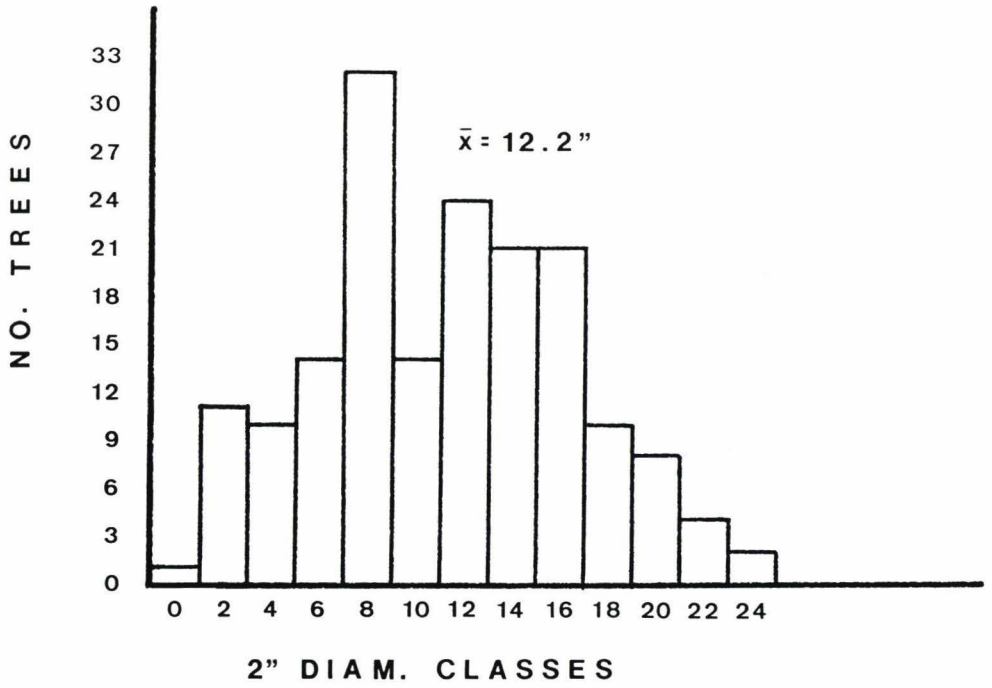

Figure 3. Diameters in 2-inch classes of 172 dead spruce cored on monitoring plots. Glacier Bay National Park 1986.

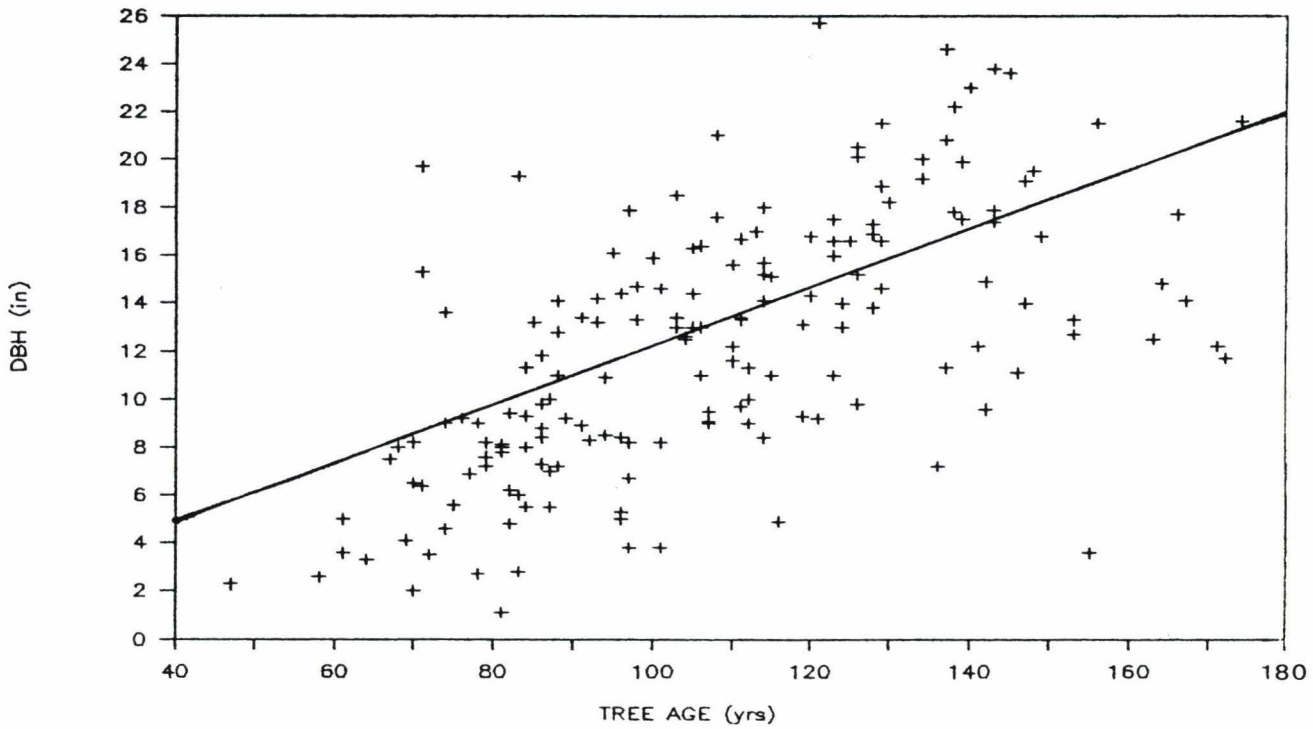

Figure 4. Regression of tree age and diameter for 172 dead spruce on fifth-acre monitoring plots. Glacier Bay National Park, 1986.

Recently, extensive work has been done in other Alaskan forests which relates spruce growth rates to attack by bark beetles (Hard 1985; Hard and Holsten 1985; Hard et al 1983). These authors have found that slowly growing spruce are most susceptible to bark beetle attacks. In white spruce stands, virtually all of the spruce mortality to bark beetles occurred where the average radial increment for the last five years was less than four millimeters (Hard et al 1983). Stands with average five-year growth rates in excess of five millimeters had no tree mortality and very few trees attacked. Watson (1928), studying spruce beetle in eastern Canada, also found a strong relationship between radial growth over a 10-year period and the ability of white spruce trees to resist bark beetle attack. Trees killed by the spruce beetle averaged 0.6 mm of growth per year, while surviving trees averaged 0.95 mm of radial growth per year. In Glacier Bay, only six of the 172 dead trees we cored had growth rates in excess of four millimeters in the five years preceding their death. The pre-death growth rates of Sitka spruce from Glacier Bay were plotted in five, 10, and 20 year increments (Figure 5). Radial growth per year has been declining on young as well as old trees for the last 40 years in the lower bay. Even 40 years ago, annual growth rates of all spruces we cored were well below the 1 mm/yr rate considered by Hard (1983) to be vigorous growth in white spruce (Figure 5).

Deterioration of dead trees

In areas of heavy spruce mortality some of the dead trees have been subject to windthrow and/or stem breakage. Sixty-six dead trees (7.3% of the total dead spruce) have broken off at the main stem or have been blown over by wind. Stem breakage has been far more common than uprooting, with the average dead tree breaking off at about 30' above the ground. This deterioration has been most pronounced in the areas where spruce mortality has been occurring for the longest time, as shown in the table below:

Table 3

Incidence of stem breakage and windthrow
in six sampling areas of spruce mortality in
Glacier Bay National Park

Area	# dead spruce	# stems broken	% of dead spruce broken
Berg Bay	42	2	4.8
Ripple Cove	91	5	5.5
Lester Island	549	30	5.5
Bartlett Lk Tr	32	3	9.4
S. Bartlett Cove	68	3	4.4
Young Island	117	23	19.7
Total	899	66	7.3

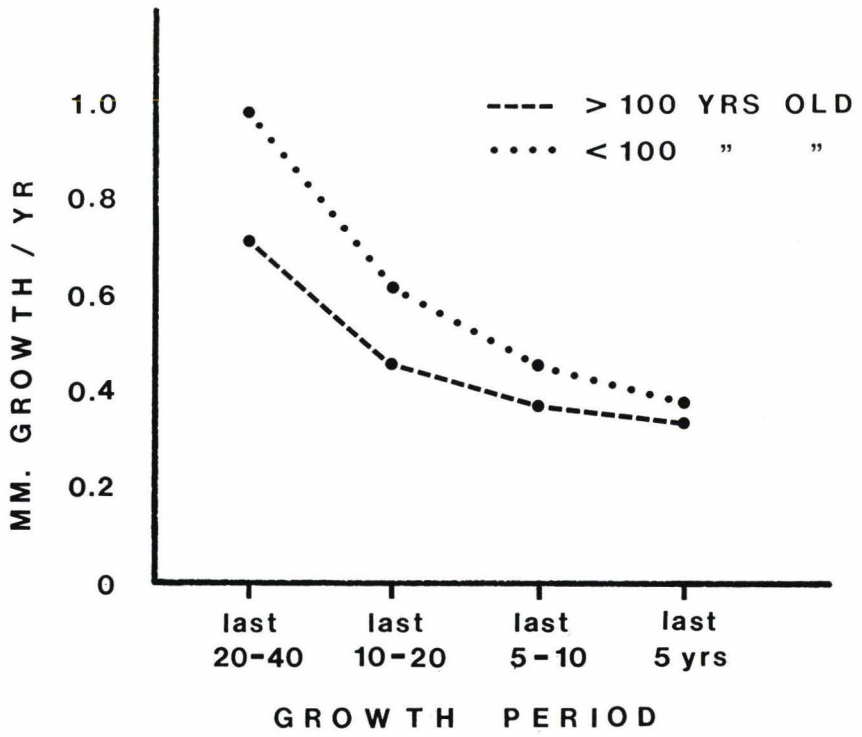

Figure 5. Five, ten, and twenty-year growth rates for trees cored on Glacier Bay monitoring plots.

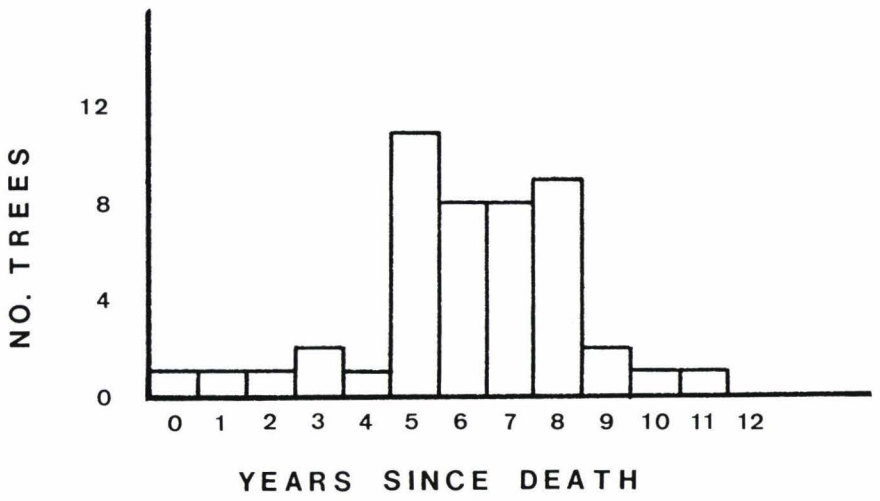

Figure 6. Number of trees with stem breakage and years since time of death on 45 monitoring plots in Glacier Bay National Park. 1986.

Nearly one-fifth of the dead trees on the Young Island plots have sustained stem breakage. Many of the trees in this area died in the late 1970's and early 1980's, and have been weakened considerably by stem decays. It can be expected that the further deterioration of other dead spruce will occur at a rapid rate in the next few years. Figure 6 shows that most trees suffering stem breakage have been dead for about six or seven years. The beetle infestation produced an extensive amount of spruce mortality in 1982 and 1983, and most of these trees are now standing but may fall within a few years.

Tree climbing data

Spruce beetle attacks on dying spruce did not follow a consistent pattern. On half of the trees we climbed, we found greater spruce beetle activity above breast height than at or below breast height. On another 30% of the trees, spruce beetle attacks were lower above breast height than at breast height. Only one out of every five trees climbed had comparable beetle attack levels between breast height and higher in the tree. In most areas, spruce beetle attacks are concentrated in the lower bole (Watson 1928; Hard and Holsten 1985; Schmid and Frye 1977). In eastern Canada, Watson (1928) noted two distinct attack periods, the first of which concentrated on the lower 30' of the bole, and the second filling in above the early attacks, and possibly at the base of the tree. Schmid and Frye (1977) report that in the Rocky Mountains, the spruce beetle attack densities decline from the base up the bole, and rarely exceed 40 or 50 feet up from the ground. Hard and Holsten (1985) also noted greater attack densities lower in the bole, probably due to reduced tree resin response at that level. In Glacier Bay, where host resistance response (or resin flow) is extremely weak, beetles were able to establish successful galleries at 35 feet above the ground in many trees. In many cases there were intermingled broods of spruce beetle and secondary bark beetles, including primarily Hylurgops rugipennis and some Ips spp. The secondary broods were also variable in their distribution, sometimes being more concentrated high in the tree, and sometimes concentrated in the lower bole. The abundance of secondary bark beetles in portions of the bole normally occupied by the spruce beetle suggests that the spruce beetle populations are fairly low and that tree resistance is extremely weak to permit colonization by the less agressive beetles.

Future work

We will continue to monitor the fifth-acre plots, but at less frequent intervals since the spruce beetle infestation appears to be declining in areas where the plots are located. It has been demonstrated through out monitoring of the plots that many trees (perhaps 30%) have died with little or no involvement by the spruce beetle. Accordingly, future work should be done by a qualified plant physiologist or soil scientist to examine the growing conditions and nutrient cycling mechanism in the lower bay, and how these factors contribute to the spruce mortality in the area.

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